

Reducing Material Wastes in Building Construction Sites: An Action for Sustainable Development

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Abstract.

Construction material waste has both environmental and cost performance consequences. In this period of global economic recession and environmental awareness, it has become necessary to adopt effective waste reduction strategies in order to reduce the cost of construction projects as well as produce environmental friendly projects. The aim of the study is to identify the effective waste reduction methods in building construction sites so that developers and construction professionals can key into the different methods in order to bring about qualitative project delivery and enhanced sustainable development. Reviewing some literatures related to the topic, the study identified the sources of construction wastes, the implications of wastes and ways of controlling them. The review equally revealed that consciousness of the implication of waste is very little appreciated considering the fact that the level of environmental awareness and willingness to pursue the goal of sustainability in the country is low. In view of this, the study concludes that efforts at adopting green practices may not advance so much, as such it recommends that the Nigerian Building and Road Research Institute (NBRRI) should intensify efforts at coming up with better green practices and selling same for government approval, adoption and implementation across the country. Secondly, every construction projects must include a waste management plan as part of the prerequisites for their approval.

Keywords: Environmental Awareness, Green Practices, Sustainable Development, Waste Reduction

1. Introduction.

The construction industry contributes immensely to the development of any nation, however, in spite of the benefits it brings, it is equally known for producing immense amounts of wastes (Thurnau, 2013). The Modular Building Institute (MBI, 2011) has confirmed that the waste generating capacity of the industry in the US is staggering, amounting to about 135 million tonnes of debris to landfills every year. Similarly, Gray (2013) reported that the industry in the UK contributes about 36 million tonnes of debris to landfills every year, which is estimated to be about 35% of the total waste produced in the UK; she also predicted that if the trend is left unchecked in the next six years, the UK landfill sites would have been exhausted.

Furthermore, Poon, Yu and Jaillon (2010) reported that Hong Kong is running out of both reclamation sites and landfill spaces for the disposal of construction and demolition (C&D) wastes. Also, Reardon, Fewster and Harkenness (2013) reporting the survey by (Hyder Consulting, 2011), revealed that approximately 19 million tonnes of building and demolition waste was generated in Australia from 2008–2009. Out of this figure, 8.5 million tonnes (45%) went to landfill while 10.5 million tonnes (55%) was recycled. This, therefore implies that the ratio of disposed waste to recycled ones in Australia is high (0.81) and represents huge financial and resource deficit to the country. Although statistics are unavailable to quantify the amount of wastes generated on construction sites in Nigeria, a similar submission by Oladiran (2009) confirms that materials wastes pervade the Nigeria's construction sites. In fact anecdotal evidence reveals practices such as poor storage system, poor material control and wrong material specification which generate waste and increase construction cost. Apart from overburdening the limited landfill sites as Gray (2013), MBI (2011) and Poon, Yu and Jaillon (2010) revealed, material wastes result to unnecessary high construction costs and great hindrances to affordability of good houses to the citizens (Oladiran, 2009).

Reports from Reardon, Fewster and Harkenness (2013) and Gray (2013) show a concerted attempt by Hong Kong, Australia, Germany and Denmark at recycling waste. Other developed countries like the US and UK are entrenching sustainable measures for minimizing waste (Gray, 2013), however much is left to be done in reducing waste in Nigeria considering its low environmental awareness (Wahab and Lawal, 2011). As the world faces environmental problems, concerns have been directed to preserving the earth's resources for the future generation therefore, it is imperative to examine ways of managing waste on construction sites so that the objectives of sustainability may be attained.

The aim of the study is to identify the effective waste reduction methods in building construction sites so that developers and construction professionals can key into the different methods in order to bring about qualitative project delivery and enhanced sustainable development. The study will, therefore, identify the different sources of waste at the construction stage of buildings, examine the implications of wastes and identify strategies for minimizing them.

1.1. Statement of the Problem.

The building/construction industry is said to be making use of considerable amount of resources (Poon, Yu and Jaillon, 2010, Wahab and Lawal, 2011, Dania, Kehinde and Bala, n.d), which have severe impact on the environment at different timescales in the building cycle (Horsley, France and Quartermass, 2003).

In Nigeria, very little consideration is given to control the generation of material wastes, and this is blamed on low environmental awareness of construction waste in the country (Wahab and Lawal, 2011). Wyatt (1978) cited in Carlos, Lucio, De Cesare and Isatto (2002) stressed that high levels of waste could result to reducing the future availability of materials and energy and create unnecessary demands on the transportation system. Bossink and Brouwers (1996) cited in Carlos *et al.* (2002) lent their support to this assertion by explaining further that some building materials and components use large amounts of non-renewable sources of energy, as well as resources that are in danger of depletion, such as timber, sand, and crushed stone. As such poor waste management practices and treatment of the environment will not only lead to a degradation of water, air and land resources but also represent a big financial burden to current and future generations (City of Whittlesea, n.d).

Furthermore, as about 30 to 70% of construction cost is consumed by materials (Khyomesh, 2011 cited in Ayegba, 2013), the need to reduce cost of construction through effective material management has become paramount more especially as Nigeria faces the period of economic recession.

2. Literature Review.

Construction material waste is mostly considered to be the by-product generated and removed from construction, renovation and demolition sites of building and civil engineering structures (Ameh and Itodo, 2013; Dania, Kehinde and Bala, n.d). Similarly, Carlos *et al.* (2002) gave the public view of waste as debris removed from the site and disposed in landfills. From a different perspective, Oyegba (2013) expanding further on Onabule's (1999) submission explained that material wastes are those materials supplied to the site for construction but were not used. The foregoing seems to support Formoso, Isatto and Hirota (1999) cited in Ameh and Itodo (2013) submission by viewing material waste as inefficiency that results from the use of resources in larger quantities than those considered necessary in the production of building. While submissions from Ameh and Itodo (2013), Carlos *et al.* (2002) consider material wastes as having direct environmental consequence with regards to disposal of the waste; the submission by Oyegba (2013) considers material waste as having direct consequence on cost performance of construction projects as well as indirect consequence on the environment.

Whichever way material waste is viewed, it will be found to have both environmental and cost performance implications.

2.1. Sources of Waste

Formoso *et al.* cited in Ghanim (2014) categorized waste according to its source, i.e., the stage in which the root causes of waste occur. They further explained that waste does not just emanate from the application and use of materials in the construction site but also from the process preceding construction, such as material manufacturing, design, material supply, and planning as well. Hence management of waste should first consider the different sources of waste and the type of waste they generate, and then apply appropriate measures to minimize them from the root.

Furthermore, Skoyle and Skoyle cited in Ghanim (2014) divided waste into direct waste which is the loss of materials arising from damage during handling or site application or which were lost during the building process and indirect waste which does not result from direct waste (physical loss of materials) but have monetary consequences. According to Skoyle (1987) cited in UK Essays (2015), indirect waste includes materials used for purposes other than that for which they were ordered like in the following cases:

- Where materials are used for purposes other than those specified (substitution).
- Where materials are used in excess of those indicated or not clearly defined in contract documents, e.g. additional concrete in trenches, which are dug wider than was designed, because no appropriately sized digger bucket is available.
- Where materials are used for temporary site work for which no quantity or other allowances have been made in the contract documentation, e.g. tower-crane bases, site paths, temporary protection.
- Where materials are used in addition to the amount required by the contract owing to the contractor's own negligence.

Generally, Masudi *et al.* (2011), Bossink and Brouwers (1996) classified waste sources into six namely: design, procurement, handling, operation and residual. These six classifications were further simplified together with their corresponding causes and presented by Bossink and Brouwers (1996) in table 2.1.

Furthermore, waste may be viewed in terms of what, when and where they occur; in this regard, Dania *et al.* (n.d) asserted that waste occurrence is dependent on the type of construction method employed, the specific materials used and the stage of construction, thus table 2.2 shows the waste expected to occur at different stages of work. They also supported the position of the Construction Industry Board (CIB, 1998) and concluded that,

waste, regardless of the type and source are generally caused by mistakes, working out of sequence, redundant activity and movement, delayed or premature inputs and products or services that do not meet customer needs.

Table 2.1: Sources and Causes of Construction Waste.

Source	Cause
Design	Error in contract documents
Design	Contract documents incomplete at commencement of work
Design	Changes to design
Procurement	Ordering error, over ordering, under ordering and so on.
Procurement	Suppliers' error
Material handling	Damaged during transportation to the site/ on site
Material handling	Inappropriate storage leading to damage or deterioration
Operation	Error by tradesperson or labourer
Operation	Equipment malfunction
Operation	Inclement weather
Operation	Accident
Operation	Damage caused by subsequent trades
Operation	Use of incorrect material requiring replacement
Residual	Conversion wastes from cutting uneconomical shapes
Residual	Off cuts from cutting materials to length
Residual	Over mixing of materials for wet trades due to lack of knowledge of requirement
Residual	Waste from application process
Other	Criminal waste due to theft
Other	Lack of on-site material control and waste management plan

Source: Garvilan and Bernold (1994), Craven et al. (1994) cited in Bossink and Brouwers (1996).

Table 2.2: Expected waste generated from conventional construction.

Construction stage	Expected major construction waste
Site clearance	Soil, rock
Sub structure work	Reinforced concrete, steel bar, concrete, wood
Super structure work	Wood, steel bar, cement, sand, aggregates, brick or blocks
Finishing work	Cement, sand, aggregates, tiles, paint, lime, mortar scatters from screeding
Infrastructure works	Bituminous materials, timber, concrete

Adapted from: Mahayuddin and Zaharuddin (2013), Masudi *et al.* (2011)

2.2. Implications of Waste

Different authors have unanimously agreed that construction materials waste has two major implications namely: environmental and cost performance implications.

2.2.1. Environmental implication

The environmental concern about construction waste proceeds from the fact that most construction materials are extracted from the earth's resources leading to so many of them being in danger of depletion (Bossink and Brouwers, 1996 cited in Carlos et al., 2002), processed by methods that pollute the environment and contributes residues that fill the limited landfill spaces available. It is, therefore important that steps must be taken to reduce dependence on construction resources that have depleting potential as it will result to further reduction of the pollution generated during the manufacturing process and waste generated during conversion process and disposed to landfills.

Much of the environmental consequence of waste is on the effective disposal of them; reports of overburdened landfills in Hong Kong by Poon, Yu and Jaillon (2010) is an attestation to environmental concerns that would arise in the future for unbridled generation of construction material wastes. Apart from this implication, scarcity of landfill sites would result to increased cost of disposal in the limited landfill spaces for the contractor (BIE, 1993 cited in Dania, Kehinde and Bala, n.d) as costs to communities for operating and maintaining landfill sites increases due to unavailability of suitable land for replacement (Reardon, Fewster and Harkenness, 2013). Furthermore, reuse options for landfill sites will be limited due to potential health hazards (Reardon, Fewster and Harkenness, 2013).

On the other hand, an unbridled use of resources through poor planning and procurement could overburden the demand on these natural resources, result in their depletion and result to scarcity and increased procurement cost. Therefore, the goal of sustainability, which is the responsible and bridled use of resources must vigorously be pursued. This can be achieved by diverting attention to alternative materials so that resources can be regenerated over time.

2.2.2. Cost performance implication.

Being an inevitable part of production (Adewumi and Otali, 2013), waste contributes as high as 15% additional cost to construction projects (Tam, Shen and Tam, 2007). The cost implication of waste stems from the fact that materials become inadequate (due to poor planning, poor handling and storage etc.), thereby requiring additional procurement which increases cost.

Furthermore, since materials account for about 30 to 70% of construction cost, and as Bossink and Brouwers (1996) stated that material wastage accounts for between 20 and 30% project cost overruns, it is therefore glaring how much threat the economic loss from construction material waste could pose to the economic growth of the nation (Adewumi and Otali, 2013). Hence an in-depth review and identification of causative factors of waste, assessment of these factors and any improvement in material wastage management on construction sites will enhance the cost performance of projects in Nigeria (Adewumi and Otali, 2013).

2.3. Waste Reduction Strategies

The best waste management strategy is to nip waste at the bud and this begins at the design stage (MBI, 2011). According to Greenwood *et.al* (2003) cited in Oladiran (2009), Shant and Daphene (2014), waste minimization connotes reducing the amount and environmental effect of waste generated by reducing the amount of materials used or re-using existing materials. They also noted that the main concern in minimizing waste is to avoid waste through designing out waste or reducing waste at source. Therefore, proper planning at the design stage will lead to the perfection of design requirements such that little or no change may be required at the construction stage, identify features with little or no functional consequence to the design and taking steps to eliminate them. Furthermore, Shant and Daphene (2014) posited that alternative construction methods and material may be incorporated during design in order to eliminate or reduce waste generated in construction. As an example, they suggested the use of modular metal form systems for concrete construction instead of timber since they can be demounted and re-used on other projects.

Ghanim (2014) and Gray (2013) also noted that identifying the forms of waste and their sources, and specifying mitigating measures for them, forms an effective way of minimizing waste; such action also forms the basis of developing a waste management plan, which is highly recommended for every construction project (Seydel, Skitmore and Wilson, 1998 cited in Shant and Daphene, 2014). The plan will, generally reflect the peculiarities of the project in terms of the nature and amount of waste anticipated and prescribe ways of managing them.

Thurnau (2013), therefore, prescribed some guidelines for construction waste management at the planning stage as follows:

- Specify waste reduction goals, targets, and documentation procedures within contracting documents.
- Identify materials that can be recycled or reused, and how those materials can be transported for such purposes. Some of the recyclable material are but not limited to metal (Both ferrous and non-ferrous), cardboard paper, plastics, wood, concrete, gravel and other aggregates etc.
- Design building dimensions to correspond with standard material sizes, especially timber. This will reduce material wasted as wood accounts for nearly a third of all construction wastes.
- Order materials to optimally fit the requirements; avoid ordering excess materials delivered to the project site. Ideally, the construction program and material schedule will guide when, what and how much to order.
- Packaging should not be used only if it is essential.
- Negotiate with suppliers to buy back any unused supplies.
- Develop methods for storing materials that will reduce their susceptibility to damage.
- Estimate how much waste a project is likely to produce and what it will cost to remove that waste in a variety of ways, such as traditional garbage collection, recycling, salvage and reuse, etc.

Waste reduction can also be enhanced by choosing alternative methods of construction such as prefabrication, modularization, and off-site construction techniques as it is an effective way to design out waste (MBI, 2011). Furthermore, an off-site production offers a better opportunity for the materials to be managed prior to leaving the factory and equally offers a much more efficient process to reduce the amount of waste sent to landfills.

Minimizing waste also requires effective material management and control and Enhassi (1996) cited in Oladiran (2009) summarized material control measures as comprising the following:

- Avoid late design variations and design effective materials handling on site; specification should be to standard sizes to minimize cutting;
- Accurate scheduling of materials to programmed delivery dates;
- Documentation should set out size, quality and delivery form of materials for estimators' consideration;
- Procurement must specify quality, quantity, delivery time and method, and packaging Effective communication between suppliers and recipient;

- Preparation of effective planning programmes;
- Establish on sites procedures for the reception of goods and plan for storage in advance. Materials of high value have to be held off-site until the last moment;
- Effective procedures for issuing of material on site;
- Training of both management and other staff.

Generally, various authors have unanimously suggested a waste reduction strategy summarized under the three Rs namely: reduce, re-use and recycle. Similarly, the UK Waste and Action Resources Programme (WARP) cited in MBI (2011) developed a waste hierarchy (Figure 2.1) that advocates as follows:

- **Reduce** waste generation by proper planning, ordering to requirement, proper storage and handling;
- When it is absolutely difficult to reduce waste, products and material can be **reused** either for the same or for different purposes;
- If this is impossible, value should be recovered from waste through **recycling and composting** or energy recovery from the waste;
- If none of these solution is appropriate, then waste may be disposed of, using the best environmental option. (WARP cited in MBI, 2011; Department of the Environment, Transport and Regions, 2000 cited in Dania, Kehinde and Bala, n.d).

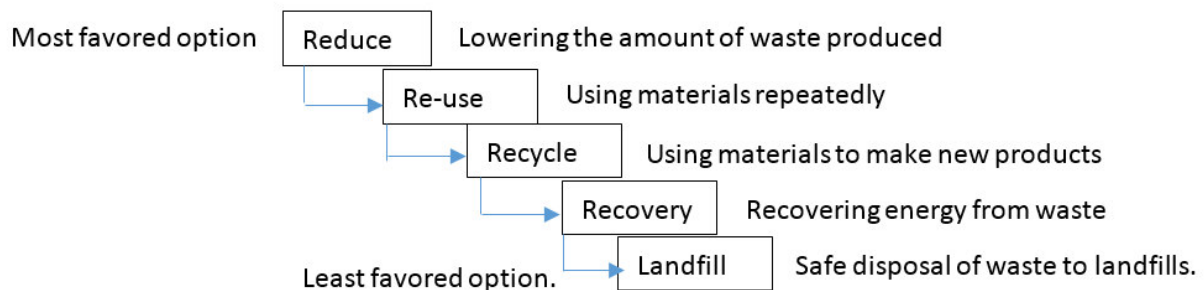


Fig. 2.1: Waste reduction hierarchy

2.3.1. Reduction

Waste minimization by reduction option is considered effective and efficient for C&D wastes as it reduces the cost of transportation and disposal (Shant and Daphene, 2014). Business Division (2013) advised that the first step in cutting the amount of waste that ends up in landfills is to reduce the quantity produced. Reardon, Fewster and Hearkeness (2013) suggested that one of the ways of reducing waste is to reduce resource consumption by building smaller houses that are better designed to suit the required need. This means that in design, additional parts that add no value to the building should be eliminated; in this way, precious resources that will be needed by future generations would be conserved and waste reduced. Also, the cost of waste transportation and disposal will be reduced as well. Other waste reduction measures as prescribed by Shant and Daphene (2014) include:

- Encourage designs that produce less waste;
- Avoid over-ordering materials.
- Use standard sizes and quantities of materials to reduce offcuts;
- Arrange for materials to arrive on site to match the work stages, to limit the chances of them being damaged through bad storage;
- Ensure storage areas are secure, safe and weatherproof.

2.3.2. Re-use

As a way of reducing the ecological footprint of construction activities on the environment, the reuse of materials that are considered waste is another effective method of reducing waste that is disposed on landfills and also contributes a major cost savings for construction projects (Shant and Daphene, 2014). Corroborating this assertion, Reardon, Fewster and Hearkeness (2013) emphasized that re-using existing buildings and materials as much as possible will reduce demand for resources, lower waste volumes and save money. In the same vein, Business Division (2013), considering throwing away perfectly good materials as unacceptable recommends for the storage of used material and re-use of them on the same site or on another project as it will enhance better environment and reduce cost. It also listed some materials with re-use potentials as including:

- Bricks and tiles (damaged items can be crushed);
- Inert materials like concrete, soil, stone, asphalt;
- Paint
- Timber and wooden pallets;
- Plaster board
- packaging

Re-use waste reduction option is not limited to re-using materials but includes actions that will reduce

further consumption of resources like renovating an existing building rather than demolishing the old one and building again from the scratch. This makes more sense because, apart from preserving some historic structures, renovation (re-using) takes lesser amount of resources than demolition and rebuilding from the scratch. Moreover, where reasons for re-use may not be appealing enough, instead of practicing demolition, deconstruction is much better as it helps in recovering materials for use elsewhere without damage (Burger, 2015). Advice such as this may be unattainable in Nigeria as the socio-cultural disposition in the society does not allow for economical or frugal living. Other re-usable strategies include the use of materials from other sites or from the site. For example, timber form may be used up to three times, brick, aggregates, concrete from demolition sites may be used for hardcore beds or as fillers for soak away pits or more still as road bases.

2.3.3. Recycle.

Business Division (2013) considers recycling as crucial in the effort to prevent valuable materials from ending up in landfill and has the potential to turn 100 per cent of non-hazardous waste back into new construction products. Recycling is the process of processing of waste for re-use. Recycling either retains the original value of the material or it impacts a different value to it, in which case the material may serve for other purposes. Construction waste management principles advocates for the recycling of resources that are left over or have reached the end of their useful life (Reardon, Fewster and Hearkeness, 2013).

The most important step for recycling of construction waste is on-site separation, in which material wastes are sorted into their different categories (Sustainable Source, n.d). In line with the foregoing, Business Division (2013) pointed segregation of waste as the key to successful recycling; it requires using different skips or containers for different materials, this will in turn enhance transportation of the wastes to appropriate processing sites or companies for recycling.

The implication of recycling is that apart from reducing the demand for new materials, the volume of waste going to landfills is also minimized. Moreover, it makes materials for construction relatively cheaper, thereby, reducing the cost of construction (Challenge for Sustainability, n.d). Hence, it is advisable to use materials with high recycling content to create a market for recycled resources (Reardon, Fewster and Hearkeness, 2013). Some common recyclable construction materials and their uses include:

- Wood, which is recycled for energy generation, animal bedding, mulch for gardens and golf courses, landscaping pellets and chipboard for new kitchen units;
- Inert materials such as bricks, concrete, soil and stones are crushed and used to produce aggregate materials and new concrete or asphalt;
- Plasterboard is expensive to throw away, but can be reprocessed to make new plasterboard;
- Metal can be recycled to make new high-quality metals, a process that uses less energy than making metals from scratch.;
- Cardboard and paper can be shredded for animal bedding or house insulation, and can be used to make biodegradable coffins;
- Plastics waste can be recycled for use in construction projects, or to make street signs and landscaping materials;
- Glass can be recycled for multiple uses, including aggregate in concrete, and insulation (Business Division, 2013).

3.0. Conclusion and Recommendations

As the global concern is to reduce the ecological foot print on the environment, much attention is directed to sustainable development, which emphasizes more on reducing man's dependence on the earth's resources and adopting alternative development in order to conserve resources for the future generation.

Secondly, in this period of deep economic recession with its attendant increase in prices of products, the need to adopt economical and sustainable construction has become very important. Furthermore, as landfill sites are being exhausted and the hope of finding replacement for them very slim, it has become necessary to reduce waste that is generated from construction activities. Various sources of construction waste have been identified to emanate from poor planning, poor material handling and storage, theft and so on.

Generally, the study has identified three key strategies for minimizing waste namely reduction, re-using and recycling. Disposal should hardly be given a thought except when the three Rs have proved inappropriate for the waste generated. Good waste management practice starts from the drawing board where waste is identified, analysed and quantified and appropriate measures prescribed to mitigate them.

However, in the light of the present situation in the country, with regards to environmental awareness and commitment to sustainable practices, the study concludes that consciousness of the implication of waste is very little appreciated, as such efforts at adopting green practices may not advance so much except drastic actions are taken.

Management of waste in all forms requires the collective efforts of both governments and stakeholders; previous efforts at environmental management and control have yielded little or no fruit as anecdotal evidence

shows that there is no concerted effort at implementing and enforcing environmental laws. As such collective effort required to make a meaningful impact may not really advance.

The study, therefore recommends as follows:

- The Nigerian Building and Road Research Institute (NBRRI) should intensify efforts at coming up with better green practices and selling same for government approval, adoption and implementation across the country.
- Every construction project must include a waste management plan as part of the prerequisites for the approval of such projects.
- That professionals in the industry, should embark on massive awareness and training of the members so as to induce the consciousness required for individual effort

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